T&E of Network Centric Warfare Systems --

A Lesson in Systems Engineering Discipline

23 October 2002

Bob Ogden
Raytheon St. Petersburg, FL
727.302.7505
Robert_J_Ogden@raytheon.com

Raytheon

Outline

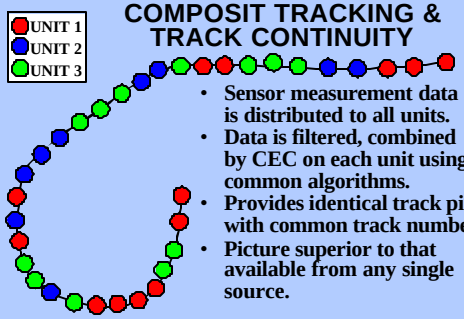
- **Brief CEC Intro**
- **Road to CEC OPEVAL T&E Lessons Learned**
- **System Engineering Processes**
- **Next Step - Larger nets, FOT&E**

Cooperative Engagement Capabilities

REVOLUTIONARY NEW CAPABILITY
- Not a New Sensor or Weapon System
- Distributes & Combines Sensor & Weapons Data from Existing Systems

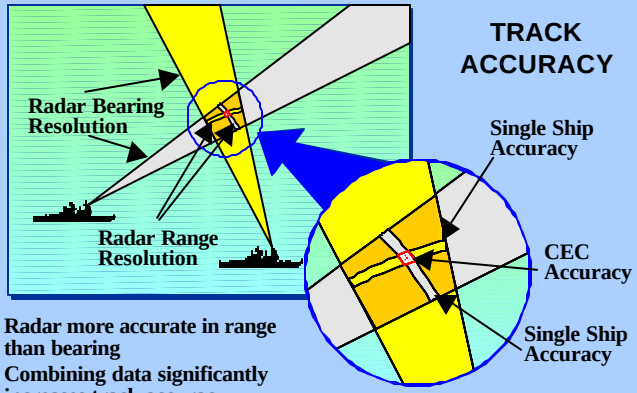
SENSOR COOPERATION

COMPOSIT TRACKING & TRACK CONTINUITY

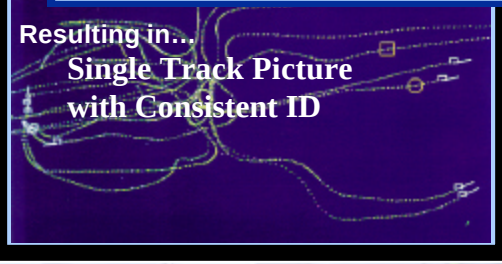


- Sensor measurement data is distributed to all units.
- Data is filtered, combined by CEC on each unit using common algorithms.
- Provides identical track picture with common track numbers.
- Picture superior to that available from any single source.

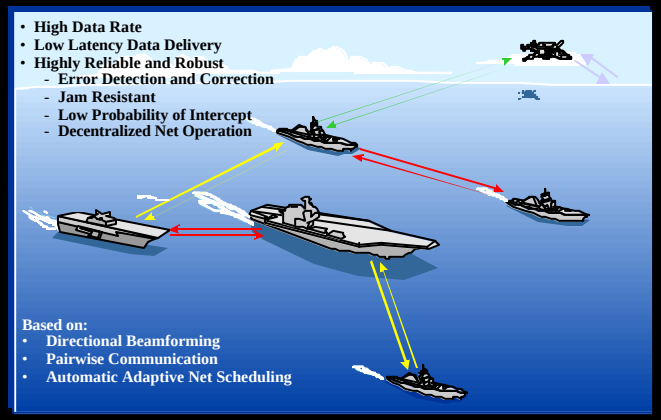
TRACK ACCURACY



- Radar more accurate in range than bearing
- Combining data significantly increases track accuracy

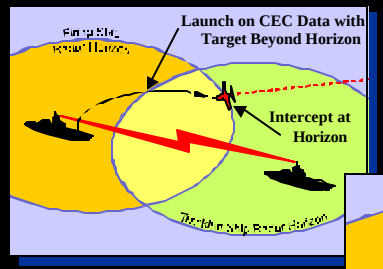


DATA DISTRIBUTION



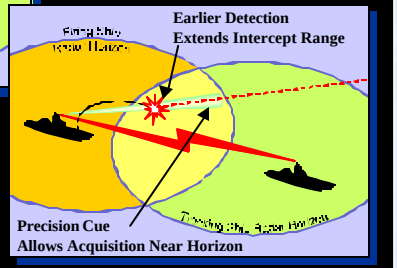
SIGNIFICANT BENEFITS
- Track Accuracy, Continuity, & ID Consistency
- Identical Picture, Track Numbers on All Units
- Reduced Reaction, Extended Engagement Ranges

COOPERATIVE ENGAGEMENT



ENGAGE ON REMOTE

CUED ENGAGE



CEC EXPANDS THE BATTLESPACE

CEC Warfighting Benefits

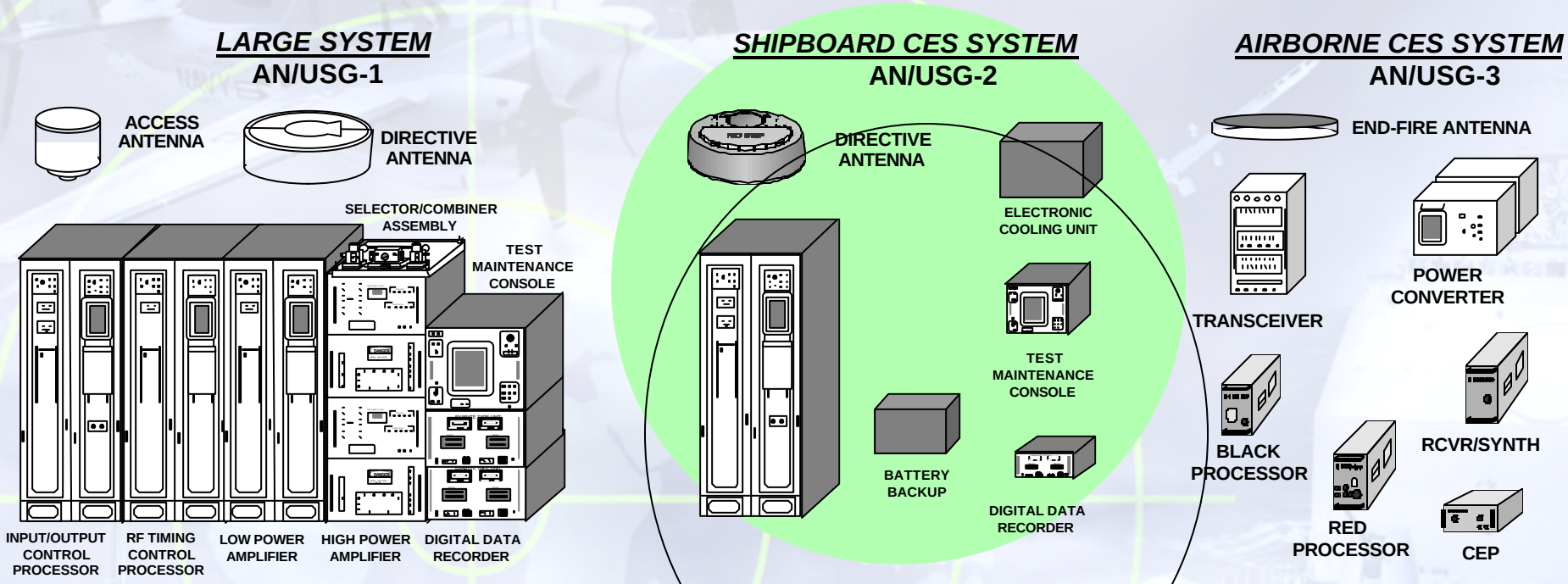
Detection and Tracking

- **Composite picture formed by combining all Battle Group sensor measurement data**
  - Tracking accuracy/target discrimination superior to any single sensor
- **Quantum improvement in track and identification continuity**
- **Remote sensor cueing extends force detection ranges**
- **Expands capability of existing sensors and weapons**

Engagement

- **Earlier track formation resulting in increased time for combat system to react**
- **Significant increases in depth of fire; higher P_k**
- **Enables self defense systems to maximize performance against stressing targets**
- **Engagement of targets not held by ownship sensors**
- **Improved ability in jamming environments**

CEC Equipment Configurations In OPEVAL



Network testing will always involve a mixture of systems

3 Different Equipment Configurations For OPEVAL

- AN/USG-1: Add'l Node - Known Limitations
- AN/USG-2: System Under Evaluation
- AN/USG-3: Add'l Node - FOT&E item

Road to CEC OPEVAL

- Lessons Learned -

- **Operational Evaluation "raised the bar" in accountability**
  - Previous CEC tests primarily proof-of-concept demonstrations or limited scope events
  - "It" worked before, IKEBG had deployed with CEC
- **All host combat systems and CEC brought new computer programs for the OPEVAL test evolution**
  - Independent testing with simulation test requires extensive fidelity to minimize risk at onset of live testing
- **No individual agency understood the magnitude of OPEVAL**
  - Stovepipe integration strategies and organizational structures (technical/programmatic) were not effective for battle force integration
- **Battle Group interoperability implications were grossly underestimated - TADIL/Host/CEC interaction**

After 3 live events, we stopped...

Getting Things Stabilized

- **Established collaborative data analysis practices with all programs represented**
  - Analysis Control Board, Data Analysis Working Group
  - Data collection required extreme measures of discipline
- **High priority problems identified for correction of system stability issues**
  - OPEVAL Change Control Board, Individual program CCBs
- **Integration solutions developed and cooperatively fielded**
  - Functional Teams, Senior Systems Engineering Council

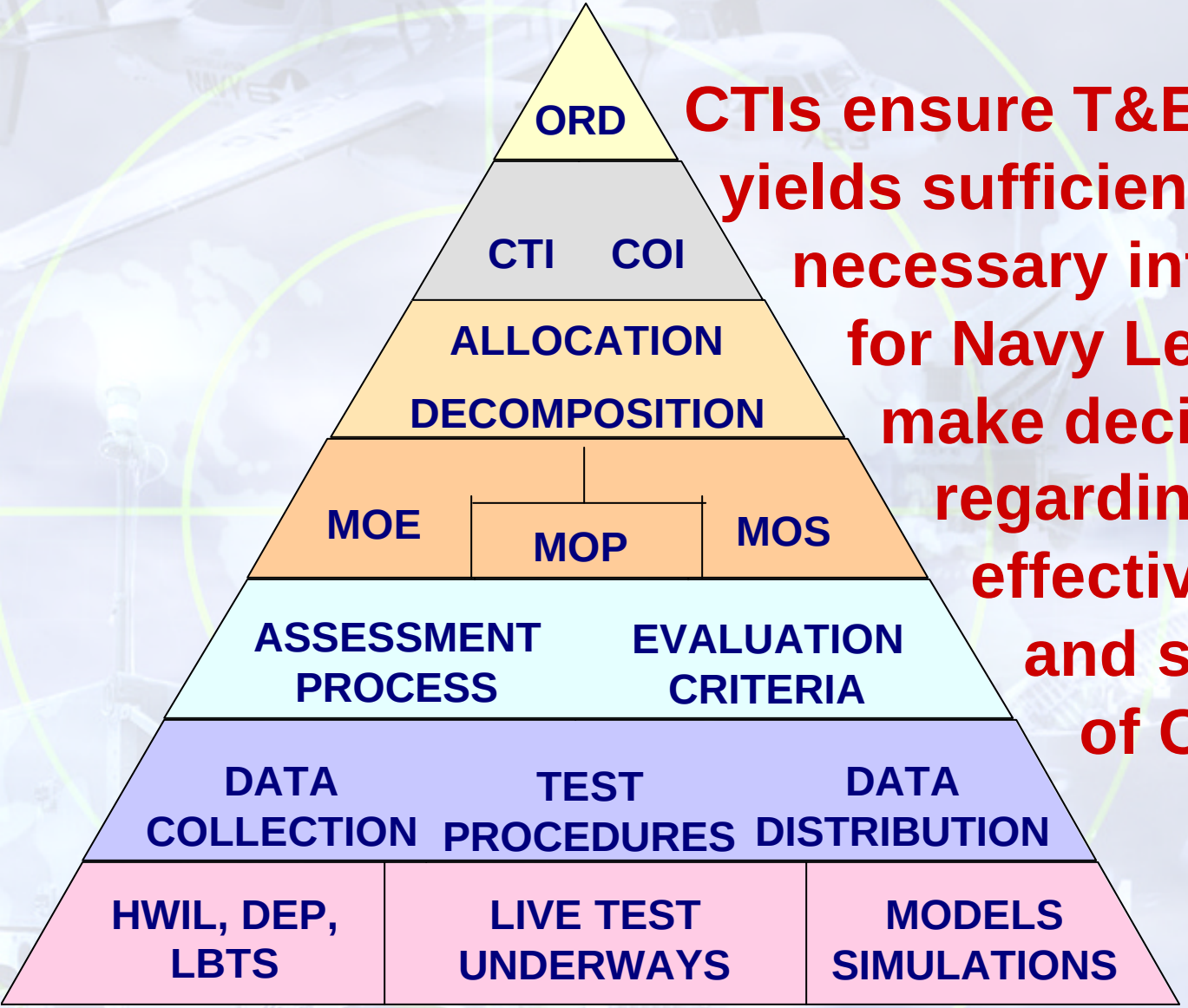
Steady state operations allowed testing to resume

The Road to Recovery

- **System-of-Systems evaluation methodology defined**
  - CEC ORD revisited
  - CEC Collaborative Analysis Process defined Critical Technical Issues - MOEs, KPPs, etc.
- **A measurable, progressive test strategy developed**
  - Test Control Board, Scenario Working Group
  - TADIL interoperability isolation tests established perspectives
- **Centralized control at a level to influence all programs was critical**
  - PEO-TSC Interoperability Task Force established
  - Program Managers Advisory Council
  - Senior Advisory Group
  - Operations Advisory Group

Managing scope and expectations at all levels

CTI Framework



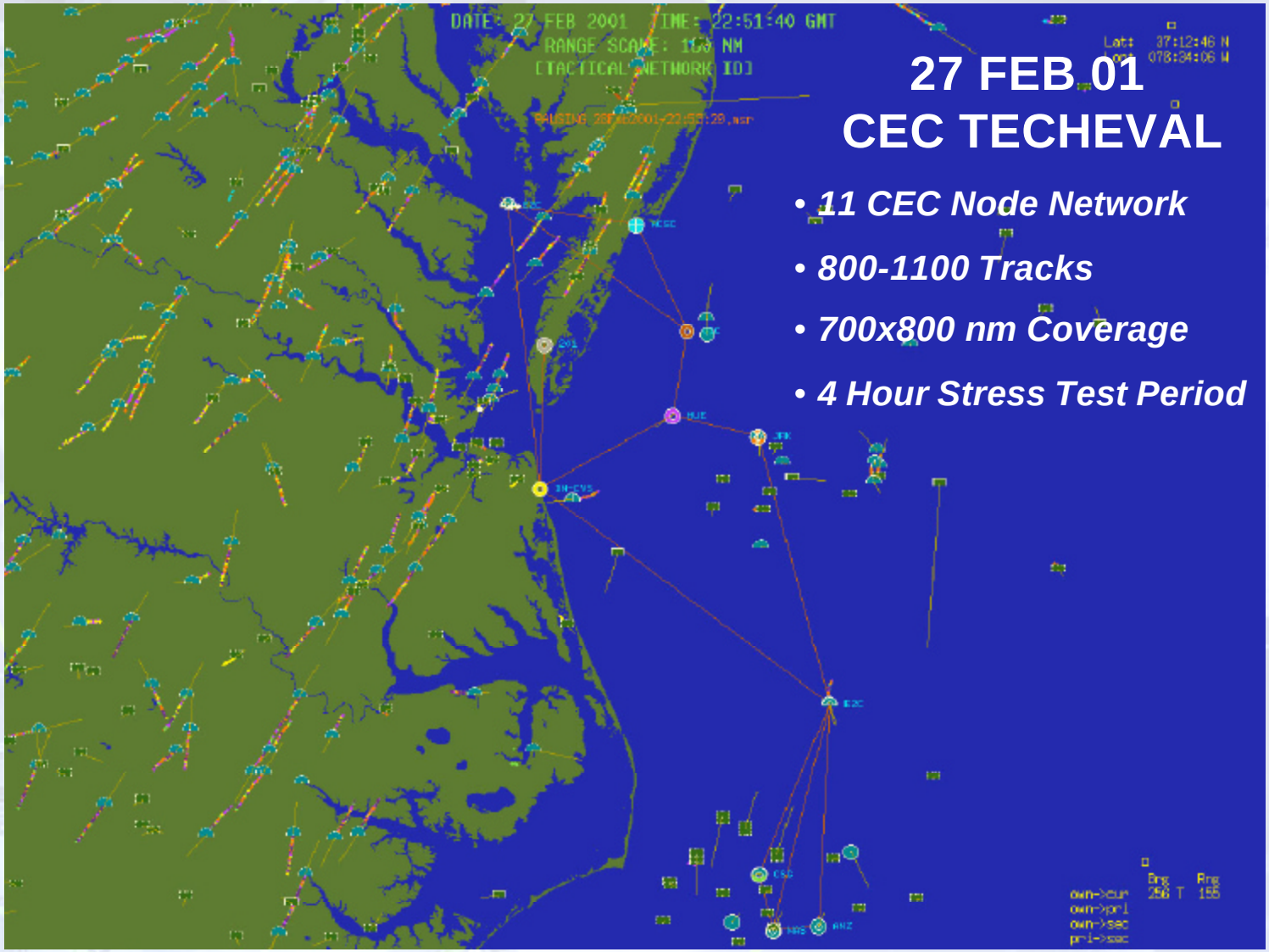
CTIs ensure T&E process yields sufficient and necessary information for Navy Leaders to make decisions regarding the effectiveness and suitability of CEC

Making Progress

- **Measurable progress was achieved**
  - Test strategy and evaluation criteria were set
  - Baseline performance evaluated
  - Practical test, evaluate, fix, verify, retest time cycles defined
  - Improvements integrated with ever tightening configuration control
  - Measurements were retaken
  - Test complexity increased
- **Entrance and exit criteria were established for each event**
- **Periodic comprehensive performance reviews**
- **System performance maturity enabled operational training and proficiency**

Systematically and progressively verified required performance

Performance Verification Complexity



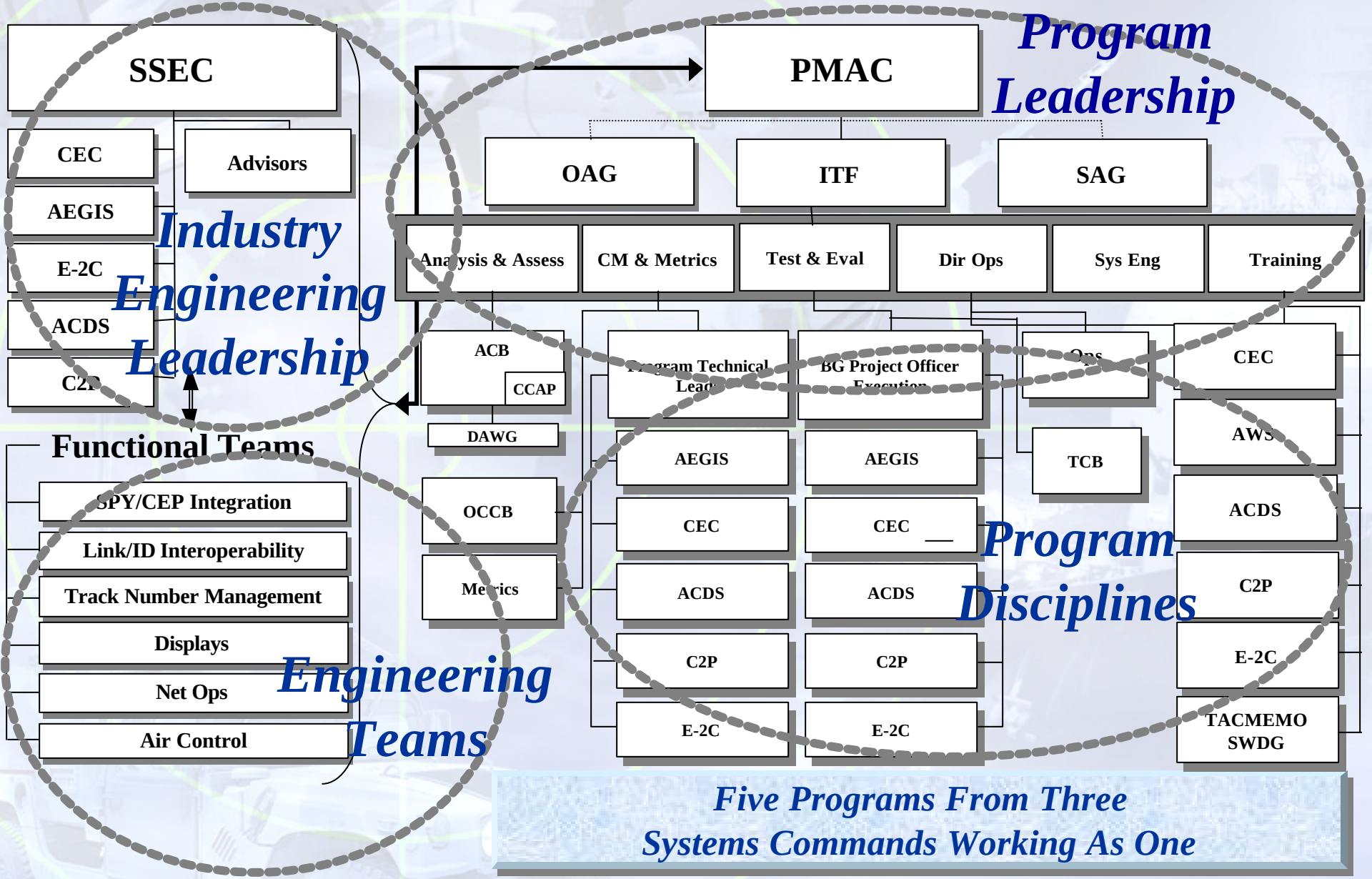
Operationally Effective & Suitable

- **Systematic engineering process clearly defined expectations and limitations**
  - No surprises!!!
- **Key performance parameters demonstrated system value**
- **Operational evaluators participated in engineering testing**
  - System under test was well characterized as were the components that comprised the system-of-systems
- **Introduction of System of Systems capabilities like CEC is an evolutionary process - FOT&E**

Systems engineering discipline is paramount to success

A System of Systems Success Story

The Road to CEC OPEVAL



Five Programs From Three Systems Commands Working As One

Affordable Growth Concepts

- **Operational network centric warfare testing is very costly**
- **Distributed Engineering Plant (DEP) leverages land-based assets**
- **Capacity testing can only be accomplished via simulation/stimulation**
- **Operational testing and training must continue at the fighting integer level**
  - For a network system the fighting integer becomes the Battle Force
  - Annual fleet and joint events minimize cost/disruption and maximize operational realism (JCIET, Roving Sands, COMPTUEX, JTFEX)
- **Engineering practices must ensure performance cornerstones are retained as networked systems become more diverse**

System engineering discipline must be flexible

Distributed Engineering Plant (DEP)

- FY 01 -

AAW FOCUSED

F-14D
PT Mugu

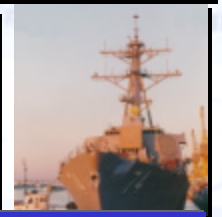
Air Force / Industry
AWACS
Boeing-Seattle

AEGIS CGs/DDGs
ATRC

DEP Operations Center
NAVSEA Dahlgren

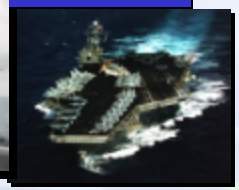
E-2C GII (Back-Up)
NAWCAD - PAX River

Battle Group LINK Monitor
NCTSI



AEGIS CGs/DDGs
SCSC, Wallops Island

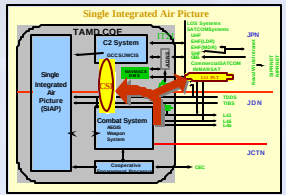
E-2C GII
SSC - San Diego SIF



AEGIS CGs/DDGs
NSWCDD - ACC

CV/CVN Class
LHA/LHD Class
DD/FFG Class
NSWCPHD / Dam Neck

C4ISR
SSC-Charleston / SD



CV/CVN Class
LHA/LHD Class
ICSTF - San Diego

U.S Army
PAC-3
Huntsville

D-30 Process Overview

FLEET CINCs
Battle Group Composition Established
D-30

INITIAL BASELINE REVIEW
Initial Baseline Configuration Defined
D-28

BASELINE REVIEW BOARD
Final Baseline Configuration Promulgated
D-24

PLATFORM CERTIFICATION
Begins
D-18

BATTLE FORCE INTEGRATION TESTING (BFIT)
Distributed Engineering Plant Testing
D-12

PRELIMINARY BATTLE GROUP CERTIFICATION
Baseline Hardware/Software Install/Preliminary Certify
D-7

FINAL BATTLE GROUP CERTIFICATION
Final Baseline Hardware/Software Certification
D-1

ELECTRONIC CHANGE CONTROL BOARD (eCCB)
CONFIGURATION PLANNING GROUP (CPG)
D-24 to D-0

Battle Group Centric

"CARDINAL RULES"

- *NOTHING GOES ONBOARD WITHOUT GOING THRU DEP TESTING*
- *NOTHING GOES ONBOARD AFTER PRE-DEPLOY AT SEA EXERCISE (COMPTUEX/JTFEX)*

The Solution to System of Systems Success

Systems Engineering & Management

At All Levels